MINISTRY OF WATER AND IRRIGATION

Water Resource Policy Support

SUMMARY OF THE WATER RESOURCE POLICY SUPPORT ACTIVITY

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His Excellency The Minister of Water and Irrigation, Dr. Hazim El Naser,
Eng. Fayez Bataineh, Acting Secretary General, Ministry of Water and Irrigation,
Eng. Edward Qunqar, Water Resource Director, Ministry of Water and Irrigation,
Eng. Suzan Taha, Director of Management Information, Ministry of Water and Irrigation,
Eng. Nazeer Abu Arqoob, Director of Environmental Studies, Ministry of Water and Irrigation,
Ms. Cecily Mango, Water Resources and Environment Director, USAID/Amman,
Mr. James Franckiewicz, Water Resources and Environment Director, USAID/Amman,
Dr. Amal Hijazi, Cognizant Technical Officer, Water Resources and Environment USAID/Amman, and
Dr. Robert Yoder, Program Coordinator, ARD Inc.

SUMMARY

The Water Resource Policy Support activity, a joint effort of the Ministry of Water and Irrigation, ARD Inc., and the United States Agency for International Development, focused on supporting the implementation of water policies, through the development of a groundwater management action plan and of a plan for managing water reuse.

A groundwater management action plan for the Amman-Zarqa Basin (AZB) Highlands addressed the issue of how to reconcile the current over-exploitation of groundwater resources in the AZB with rapidly-increasing demands, through proposing the following activities (listed in increasing order of difficulty of implementation):

- reductions in groundwater abstraction for agriculture in the AZB Highlands by instituting an irrigation advisory service, implementing a wells buy-out program, and the enforcement of abstraction limits;
- exchange of groundwater with treated wastewater; and
- reductions in abstraction for municipal and industrial use.

A plan for managing water reuse in the Amman-Zarqa Basin and the Jordan Valley addressed the issue of how to best use the expected increases in volumes of reclaimed water produced in the AZB over the next twenty-five years, through proposing the following uses (listed in proposed sequence of implementation):

- existing uses of reclaimed water to continue to be met at least at the same levels for agriculture in the Middle Directorate and stage office 6 of the Karameh Directorate of the Jordan Valley, and in Wadi Zarqa downstream of As Samra;
- fully meet the needs of preexisting allocations that have not yet been met. These are the options to allocate further reclaimed water for agriculture to Stage Offices 4, 5, and 8 of the Middle Directorate of the Jordan Valley, to Wadi Zarqa downstream of As Samra, and to the Hashemite University;
- exchange with groundwater, and meet future demands for industrial and municipal reuse, in the Hashemite-Zarqa area of the AZB Highlands;
- exchange with surface water for agriculture at Stage Office 3 of the Middle Directorate, and in the Northern Directorate (Stage Offices 1, 2, and 7), of the Jordan Valley;
- intensification and expansion of irrigated agriculture in the Karameh (Southern) Directorate of the Jordan Valley (Stage Offices 6, 9, and 10);
- exchange with groundwater for agriculture in the Dhuleil–Hallabat area in the AZB Highlands; and
- development of commercial irrigation at the Basin's minor wastewater treatment plants.

The management plans present practical and implementable solutions to the issues addressed, particularly because they are based on extensive collaboration with stakeholders; they include a comprehensive series of supporting actions designed to sustain the implementation of the identified management options; and they consist of a series of pre-feasibility level studies which included extensive technical reviews and the implementation of specific technical studies. This material represents a secure basis on which to proceed with feasibility-level studies for any of the selected options.

The capacity of the MWI and related stakeholders to implement policy was improved during the project period through MWI/ARD team and stakeholder efforts in developing the plans; through specific formal training activities; and through assistance with data management, including support to the new Laboratory Information Management System at the WAJ Central Laboratory.

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LIST OF ABBREVIATIONS

ARD	Associates in Rural Development Inc.
AZB	Amman–Zarqa Basin
BOD_5	Biochemical Oxygen Demand, Five Day
COD	Chemical Oxygen Demand
DEH	Directorate of Environmental Health
DFS	Directorate of Food Safety
DO	Dissolved Oxygen
ECC	Economic Consultative Council
EUREP	Euro-Retailer Produce Working Group
Fil	Unit of currency, equals 1/1,000 of a JD
FCC	Fecal Coliform Count
GAP	Good Agricultural Practices
GIS	Geographic Information System
GMCC	Groundwater Management Consultative Committee
GMF	Groundwater Management Fund
GPS	Global Positioning System
HDH	Hashmiyah–Dulayl–Hallabat
IAS	Irrigation Advisory Service
JD	Jordanian dinar (currency)
JICA	Japanese International Cooperation Agency
JV	Jordan Valley
JVA	Jordan Valley Authority
km^2	Square kilometers
KAC	King Abdullah Canal
KTR	King Talal Reservoir
LIMS	Laboratory Information Management System
m^3	Cubic Meter
M&I	Municipal and Industrial
MCM	Million Cubic Meters
MOA	Ministry of Agriculture
MOH	Ministry of Health
MWI	Ministry of Water and Irrigation
NCARTT	National Center for Agricultural Research and Technology Transfer
NGO	Non-governmental Organization
NIR	Net Irrigation Requirements
NRA	Natural Resources Authority
O&M	Operations and Maintenance
RA	Rapid Appraisal
RS	Remote Sensing
RSS	Royal Scientific Society
TDS	Total dissolved solids
TO	Task Order
UFW	Unaccounted for Water
USAID	United States Agency for International Development
WAJ	Water Authority of Jordan
WIS	Water Information System
WRPS	Water Resource Policy Support
WWTP	Wastewater Treatment Plant

WATER RESOURCE POLICY SUPPORT ACTIVITY: SUMMARY REPORT

1. INTRODUCTION

The Water Resource Policy Support activity (WRPS) was a two-year bilateral initiative (August, 1999 to August, 2001) between the Government of Jordan's Ministry of Water and Irrigation (MWI) and the United States Agency for International Development (USAID). The WRPS was supported through a contract between USAID and Associates in Rural Development, Inc. (ARD), under the Integrated Water and Coastal Resources Management Indefinite Quantity Contract (USAID Contract No. LAG-I-00-99-00018-00, Delivery Order No. 800).

This report summarizes the results of the program, and the resources and procedures used to achieve these results.

The two overall aims of the WRPS were to design, institute and support

- a program for sustainable management of upland aquifers and the use of water resources in the upper Amman-Zarqa Basin, and
- a practical wastewater reuse program for the Amman Zarqa Basin and the middle area of the Jordan Valley.

These aims addressed some of Jordan's major issues of water management: how to reconcile the current over-exploitation of groundwater resources in the Amman-Zarqa Basin (AZB) with rapidly-increasing demands, and how to effectively increase the role of treated wastewater in meeting demand in the AZB and in the Jordan valley.

Secondary aims of the WRPS, relating to general support for the MWI, were

- to institutionalize sustainable operational procedures for the acquisition, management, analysis, and utilization of data required to optimize management of Jordan's water resources,
- to provide a sound data and information base for policy analysis and formulation, and
- based on reliable data, to establish and carry out analysis and planning for efficient management and allocation of Jordan's water resources through provision of technical assistance, training, limited commodity procurement, and other related services.

Program activities were based on the original Statement of Work and contract budget, which was used as the basis for the initial draft workplan (MWI/ARD, January, 2000), and a budget modification in March, 2000. The program was slightly modified in the second year workplan (MWI/ARD, Annual Workplan: August, 2000, - August 2001), with a resulting budget modification in March, 2001.

The main changes from the original Statement of Work, represented by the workplans which were developed with the full participation of MWI, USAID and ARD staff, were:

- a stronger focus on developing two specific management plans: for reducing groundwater abstraction for irrigation in the Amman-Zarqa Basin Highlands, and for most effectively using the increased future volumes of reclaimed water in the Amman-Zarqa Basin and Jordan Valley,

- the addition of the Northern and Southern Directorates of the Jordan Valley as potential areas for further use of reclaimed water,
- the addition of a review of brackish water resources in the Amman-Zarqa Basin,
- the addition of training programs for MWI staff in remote sensing and groundwater modeling, and
- the planning for, but not implementation of, pilot schemes in the AZB Highlands.

The main strategy for implementation of the program was to focus all activities on developing the two management plans:
- a groundwater management action plan for the Amman-Zarqa Basin Highlands, and
- a plan for managing water reuse in the Amman-Zarqa Basin and the Jordan Valley.

These plans were developed by forming a joint team with MWI staff, usually either for a "groundwater" or a "water reuse" focus, for review of existing documents and data, undertaking technical studies, and involving stakeholders. The groundwater and water reuse teams collaborated throughout this process, as many of the technical studies applied to both teams and some management options were common to both teams.

For the general support activities to MWI, the operational strategy was to support the MWI in building up its capacity to sustain water policy implementation activities in general, using as a basis the specific tasks related to development of the two management plans.

Periodic meetings/presentations of the MWI/ARD team, and between team members and stakeholders, ensured that development of the plans was shared and vetted by all participants.

Stakeholders were involved in the process from the outset, playing an important initial role in identifying practical management options. Following repeated contacts with individual stakeholders during the first year, consultations with groups of stakeholders and community leaders became a more important forum during the second year, as the outline of the management plans became clearer, and as technical and administrative support grew for priority options.

When the draft plans had been formulated, more than eighty stakeholders - community leaders, farmers and other users, the Head of the National Farmers Union and its representatives in the AZB and Jordan Valley, farm managers, local and national government representatives and staff of independent institutions - participated in a comprehensive meeting, to review the plans.

The planning process for each of the groundwater management and reuse management plans: involved:
- Defining the objectives of the management plan
- Defining the options for achieving management objectives
- Describing and assessing each option
- Proposing combinations of options (alternative scenarios) that would best achieve management objectives, given assumed future conditions
- Defining actions which would support implementation of selected scenarios.

Each stage of the planning process involved the review of available documents, the implementation of technical studies, and the participation of stakeholders.

2. RESOURCES

The national and international staff contracted under the program are detailed in Appendix 1. Three international long-term positions, a Chief-of-Party, a Groundwater Specialist who provided leadership for the groundwater plan, and a Water Reuse Specialist who provided leadership for the water reuse plan, were filled for almost all of the project period, and total level of effort was approximately seventy person-months. Thirty-eight international short-term staff were employed, with twenty of these being repeat visits, for a total of approximately forty-six person-months; these visits concentrated on the technical and economic assessment of potential future management options for groundwater and reclaimed water. Nine long-term national technical staff were employed for a total level of effort of approximately one hundred and twenty person-months, divided approximately equally between Water reuse engineers, groundwater engineers/specialist, and computer-related support; these staff provided crucial and continuous long-term technical support to the teams. Eleven national short-term staff were employed for a total level of effort of approximately thirty person-months; these staff concentrated on providing valuable specialized assistance to the assessment of the potential management options. These staff were supported by five long-term national support staff, filling four positions (two driver/facilitators, and two administrative staff) for a total level of effort of approximately seventy-five person-months.

The more than 350 items of equipment purchased, or inherited from other projects, by the program is detailed in Appendix 2. The equipment includes five vehicles; computers/software, furniture and accessories for twelve offices; office accessories such as photocopiers and telephones; projection equipment; and minor field equipment. Approximately half of the value of the equipment consists of direct assistance to MWI and WAJ counterparts, and to the data management program, through the purchase of well rehabilitations, field and laboratory equipment, and computers/related equipment.

Approximately 3.4 million U.S. Dollars were spent on the program: on employing the above staff and purchasing equipment; on training events; on vehicle and other operating costs; and on office supplies. In addition to the above expenses, the MWI contributed office space with associated utility costs, equipment, and significant staff time.

3. GROUNDWATER MANAGEMENT ACTION PLAN FOR THE AMMAN-ZARQA BASIN HIGHLANDS

3.1 Activities

The activities of the MWI/ARD Groundwater Management Team were largely focused on developing the groundwater management action plan for the Amman-Zarqa Highlands (MWI/ARD, "Groundwater Management Action Plan for the Amman-Zarqa Basin Highlands", 12 July, 2001) through a series of technical studies and consultation/review with stakeholders. The sequencing of the main activities implemented to develop the plan is explained in the second-year workplan (MWI/ARD, Annual Workplan: August, 2000 – August, 2001) and is summarized in Appendix 3. The background reports of the technical studies, and the plan itself, are referenced in Appendix 4.

The team initially concentrated on characterizing present and future groundwater resources through a summary review of the hydrology of the AZB (MWI/ARD, "Outline Hydrology of the Amman-Zarqa Groundwater Basin", May, 2000), and through groundwater modeling. The team then implemented a Rapid Appraisal of the AZB Highlands area, and thereby built a profile of the water users and water uses in the basin to support decisions on groundwater management actions (MWI/ARD, "Planning of Rapid Appraisal of Groundwater Use in the Amman-Zarqa Basin", 18 April, 2000; and MWI/ARD, "Study of Groundwater Use for Irrigated Agriculture in the Amman-Zarqa Basin Highlands", January, 2001). The Rapid Appraisal provided the empirical background for many of the later technical studies, and ensured that stakeholders were involved in the early identification of management options. It is widely recognized that the reduction of agriculture water use in the highlands is a politically difficult and challenging task; consequently, the Rapid Appraisal played a key role in ensuring the full participation of MWI, water users, and other relevant stakeholders in the exploration of management options and the development of the groundwater management plan.

The next step was to quantify agricultural groundwater use, based on crop-water requirement and crop-water applications obtained largely from the MWI database, the Rapid Appraisal, and estimates of cropped area obtained via Remote sensing (Wood, Lynnette, "Remote Sensing Training and LandSat Image classification", October, 2000). These results were incorporated into subsequent reports.

The team then characterized and assessed the potential impact of the priority groundwater management options, including an extension/irrigation efficiency study (Hanson, R. Blane, "Technical Report: Irrigation Advisory Services Program in the Highlands Area", August 31, 2000), a water metering study (MWI/ARD, Groundwater Abstraction Metering and Monitoring, Amman-Zarqa Basin", June, 2001), and exchange of groundwater for treated wastewater (from the water reuse component: MWI/ARD. 2001m. "Plan for Managing Water Reuse in the Amman-Zarqa Basin and the Jordan Valley"). Other options such as buy-outs and abstraction limitations were assessed through the three social studies (Fitch, J.B., "Curtailment of Groundwater Use for Irrigated Agriculture in the AZB Highlands: An Economic Analysis; Jabbarin, Amer, "Curtailment of Groundwater Use for Irrigated Agriculture in the AZB Highlands: A Socio-Economic Analysis"; and Jabbarin, Amer, "Curtailment of Groundwater Use for Irrigated Agriculture in the AZB Highlands: An Agricultural Marketing Analysis"). These social studies were also used to define and assess

scenarios with the results of the hydrogeological modeling study (MWI/ARD, "Hydrogeological Impacts of Overpumping and Assessment of Groundwater Management Options in the AZB Highlands"). An assessment of the legal aspects of groundwater management options was also completed (MWI/ARD, "Legal Assessment of the Groundwater Management Recommendations in the AZB Highlands"). Actions that would support the implementation of the plan were also studied and presented as parts of the above reports, in addition to separate reports such as MWI/ARD, "Rehabilitation and Upgrade of the Groundwater and Wadi Flow Monitoring Networks, AZB", and MWI/ARD, "Assessment of Potential Use of Brackish Water for M&I Supply in the AZB".

The results of all of these studies were integrated into an interim report in April, 2001, and following presentations and reviews by the Team and stakeholders, and the completion of the remaining technical studies, a first draft plan was completed in June, 2001, and – after further review – finalized as the July 12, 2001, groundwater management plan.

3.2 Results

Characterization of Groundwater Resources

AZB aquifers have the highest groundwater recharge (88 million cubic meters, or MCM, per year) in Jordan, and represent about 30% of the nation's renewable groundwater resources of 275 MCM/year. A significant part of the recharge is groundwater inflow from Syria, with the remainder accounted for by local rainfall and intermittent runoff. Around 70 MCM, or 80% of the total AZB groundwater renewable resource, are in the Basalt and the B2/A7 aquifers, which are located in the northeastern highlands extending north to the Syrian border and southwest to the outskirts of Amman over approximately 2,420 km^2.

Groundwater abstraction in the AZB exceeded safe yield (88 MCM) by 55% in 1989, increasing to over 70% (150 MCM) in 1998, according to MWI database information. The bulk of pumping (125 MCM) occurs in the highlands, with 48% for irrigation, 46% for domestic supply, 4.5% for industrial, and for 1.5% pastoral. Nearly 90% of AZB irrigation water use is in the highlands. By 2002, overabstraction in the AZB highlands will reach nearly 100% with the development of the new Corridor wellfield located North of Hallabat, which is planned to supply an additional 10 MCM for Municipal and Industrial (M&I) purposes.

The groundwater management plan therefore focuses most strongly on options for limiting abstraction in the Basalt and B2/A7 aquifers area, located in the North-Eastern Highlands of the AZB.

During the last two decades, overpumping has resulted in significant water level decline and salinity increase in the Dulayl area, drying up of springs near Sukhna, and reduced water level and water quality in parts of North Badiya. Results of the groundwater modeling study indicate that continued overpumping of groundwater in the AZB highlands over the next 20 years is projected to deteriorate groundwater quality, with drawdowns averaging 0.5 meters per year and drying up of 70% of the wells in the Hashimiya–Dulayl–Hallabat (HDH) area.

As a result of this deterioration in groundwater resources, the agricultural sector in the AZB highlands is expected to incur a total of JD52.65 millions in losses over the next 20 years, as a result of: increases in energy cost for pumping owing to drawdowns; the cost of well deepening and reconstruction; investment losses owing to the abandonment of 74 farms; and

crop yield losses owing to increased salinity. The resulting on-farm and off-farm unemployment in the area would increase significantly, with the unemployment expected to increase to 20% from its current level of 15%.

Depletion of water resources, deterioration of water quality, soil salinity that may lead to soil sterility, and reduction of green spaces owing to abandonment of farms are the main environmental problems foreseen as a result of the continued groundwater overexploitation.

Objectives of the Groundwater Management plan

Given the water resource policies of reducing groundwater abstraction to sustainable levels and of giving priority to domestic water use, and the overwhelming importance of the Basalt and B2/A7 aquifers, the groundwater management plan focuses on how best to reduce groundwater abstraction for irrigation purposes in the North-Eastern AZB Highlands. The overall management objectives are to reduce abstractions to sustainable yield levels, and to maximize benefits from the resource.

Groundwater Management Options for Reducing Abstraction

Five reduction options, identified and assessed in detail at pre-feasibility level in the management plan as technically and economically viable, are presented in the attached Summary Table.

The **Irrigation Advisory Service option** would save 15-20% of pumped water per year (this is equivalent to 5 MCM/year of savings if this option is implemented in conjunction with other options), if pumping is reduced as a result of the expected increases in irrigation efficiency. A five-year pilot scheme is proposed, and would be economically viable, costing JD300,000. The most likely implementation constraints would be the lack of clear institutional responsibility and the uncertain sustainability of the service after the pilot phase. Supporting actions such as the integrated Basin management approach and the Groundwater Management Fund would help to alleviate these constraints.

The **Wells Buy-out option** would reduce abstraction for irrigation by 15-20 MCM/year under a voluntary scheme to be implemented as part of a management plan package over seven years. The Water Authority of Jordan (WAJ) would purchase and close-down wells presently used for irrigation by farmers, involving the transfer of 100 existing wells, representing 20 MCM annual abstraction, to WAJ control. This scheme would cost 21 million JDs, compared to the value of the conserved water which is estimated to be at least 10 million JDs per year if it were to be used for municipal supply. WAJ currently has the legal authority to implement such as program. Approximately 2,500 on-farm and off-farm jobs would be lost as a result of this scheme.

The **Enforcement of Abstraction limits option** would reduce abstraction for irrigation by 10–15 MCM/year by the eighth year of implementation. Well license abstraction limits, currently being exceeded by most farmers, are not enforced, and the system of annual permits is not being used. Enforcement of a 75,000 cubic meters annual abstraction limit, if implemented in conjunction with other management options, would lead to reductions in abstraction of approximately 15 MCM/year; a 100,000 cubic meters annual limit would lead to reductions of approximately 10 MCM/year. To achieve these results, WAJ would need to exercise their legal right to issue annual renewable abstraction licenses for all private wells, and then to enforce these. Water user fees for pumping over quota, and improvements in the

well metering system would assist this process. Approximately 1,800 on-farm and off-farm jobs would be lost as a result of this scheme. An alternative to directly limiting abstraction would be to limit the cropped area; however, this would be more difficult to implement, and should not be viewed as an alternative to the proposed well metering improvements.

The **Exchange of Groundwater with Treated Wastewater option** would save 15 MCM/year, comprised of approximately 10 MCM for irrigation and 5 MCM for industrial use. It would be technically and economically feasible to deliver recycled water from As Samra to areas adjacent to the treatment plant for industrial use and to farms in the nearby Dulayl/Hashimiyah area which are experiencing rapidly-increasing salinity, and large drawdowns, so would eventually go out of business with the loss of more than 1,000 jobs. These farms also have a high proportion of tree crops (especially olives), and forages are important crops for the area's dairy enterprises, so the change to recycled water could be more readily accommodated. On the other hand, there is considerable public opposition to use of recycled water for irrigation in the Highlands, due to possible public health risks and increased groundwater contamination which may arise unless the water is treated and managed to appropriate standards. Also, current legislation does not cover the use of treated wastewater for irrigation.

The **Municipal and Industrial Reduction option,** estimated at a total of 30 MCM/year of savings**,** is potentially available through two sources: 10 MCM/year as regained unaccounted for water (UFW) resulting from reduction of physical losses owing to rehabilitation of water conveyances, and from M&I water use saving by reducing water wastage by industry, hotels, and households; and 20 MCM replaced by new water supplies such as Disi, Wehda, Zara–Main, and AZB brackish water sources. This is a second priority option, in view of the continuing scarcity of good municipal and industrial supplies, and a lack of legal coverage.

Groundwater Management Scenarios for Reducing Abstraction

The identified groundwater use reduction options were grouped into four scenarios representing alternative possible ways to implement the options. These scenarios were designed to assist decision-makers and stakeholders to move gradually toward a sustainable abstraction from the highland aquifers, starting with a minimum reduction level for Scenario 1 (the least difficult to implement) and progressing to a maximum reduction level for scenario 4 (the most difficult to implement). Scenarios 1 and 2 include three irrigation water use reduction options - namely, the Irrigation Advisory Service (IAS), wells buy-out, and enforcement of abstraction limits. Scenario 1 corresponds to a reduction of 30 MCM, which consists of 5 MCM IAS, 15 MCM buy-out, and 10 MCM enforced abstraction limit. Scenario 2 has a 40 MCM reduction corresponding to the maximum reduction of each of the three irrigation use options. Scenario 3 corresponds to a 55 MCM reduction, which encompasses the options of scenario 2 in addition to the 15 MCM of reuse option. Implementation of scenario 4 would result in a sustainable abstraction from the highland aquifers, by also considering the M&I reduction, to reach the 70 MCM safe yield level of abstraction. Thus, scenario 4 would correspond to a total reduction of 85 MCM, including all options in scenario 3 in addition to the 30 MCM reduction in M&I.

Groundwater Management: Summary of Results from Options Assessment								
Description of Option	**Expected Reduction (MCM/year)**	**Ranking of Overall Priority**	**Ranking According to Least Cost**	**Ranking According to Least Difficulty**	**Expected Benefits**	**Legal Aspects**	**Institutional Responsibility**	**Disadvantages**
Irrigation advisory	5	1	1	2	-JD3000/well (energy) -Increase in production -GW conservation -Durability of M&I supply	Indirectly covered	MWI & MOA	Difficulties of institutional establishment and sustainability
Wells Buyout	15–20	1	3	1	-GW conservation - Durability of M&I supply	Covered in WAJ Law and suggested Bylaw.	MWI & WAJ	Unemployment and associated impacts
Limiting abstraction and/or cropped area	10–15	1 3	2	3	-GW conservation -Durability of M&I supply	Covered in WAJ Law and suggested Bylaw.	MWI, WAJ, MOA	Needs intensive monitoring and management
Exchange groundwater with recycled water	15 (10 for irrigation and 5 for industrial)	1	4	2	-GW conservation - Durability of M&I supply	Not directly covered in WAJ Law or Bylaw, but mentioned in (wastewater policy document-1998).	MWI, WAJ, MOA	Cropping pattern changes Public health and environmental concerns
M & I pumping reduction	30 (10 UFW and M&I Water use saving; and 20 replaced by other supply sources such as Disi–Wehda and brackish water)	2	5	4	-GW conservation - Durability of M&I supply	Not directly covered, but articles in the Law or Bylaw deal indirectly with this issue.	MWI & WAJ	Difficult to implement, given high priority of municipal demand and dependability on implementation of other water supply projects such as Disi and Wehda dam

Supporting Actions

A series of actions designed to support the implementation of the management options and scenarios were included in the groundwater management plan, as follows:

Illegal drilling and water sale. It is necessary to enforce the ban on new well permits for irrigated agriculture, and to identify/prevent illegal private sales of water for irrigated agriculture, although these are at relatively low levels in the North-Eastern Highlands of the AZB.

Institutional Reform and Basin-Level Management. Currently, there is overlap of responsibility between the MWI and the MOA for various management options. The recommended approach is that of establishing an integrated management unit for the AZB, based on strong participation of users. This approach could be replicated in other groundwater basins.

International Management of the AZB. Groundwater abstraction on the Syrian side of the Basin has recently been increasing rapidly, and this needs to be monitored through remote sensing. However, the total abstraction on the Syrian side is still relatively small.

Creation of an AZB Groundwater Development Fund (GMF). The GMF would support the sustainability of the IAS and operation of the well metering program, and would provide incentives related to the implementation of the groundwater use reduction action plan. This fund can be generated from water conservation fees from M&I and agricultural use, water charges from private industrial wells, and overabstraction charges from agricultural water users. A preliminary estimate of GMF income is approximately JD2.5 millions/year.

Stakeholder Participation. The excellent participation to date of stakeholders in the development of the groundwater management plan should be continued through further review meetings and through representation on management and planning committees. The rapport developed to date between the main parties who would be expected to cooperate in finalizing and implementing the groundwater management plan should be further strengthened to ensure successful implementation.

Groundwater Management Consultative Committee. The formation of this committee would assist with basin-level management, and should be formed by the MWI in order to discuss, screen and implement groundwater management actions. The participation of key representative stakeholders would formalize and help sustain their participation in all stages of the process.

Cropping Patterns and Marketing. Mandatory cropping patterns are not recommended, but the MOA, NCARRT and the private sector should cooperate in promoting high value export-oriented crops, establishing more productive marketing partnerships between the public and private sectors, and strengthening the coordination between producers.

Amendment of Laws and Regulations. Amendment of current laws and regulations is urgently needed to explicitly cover existing gaps in the law related groundwater management options and supporting tools.

Monitoring of Abstraction. The most accurate and reliable method of measuring abstraction at farm level is through metering, rather than through remote sensing, or electricity consumption data. Currently, 40% of farm meters are malfunctioning due to tampering or technical problems,

and many others are inoperable due to the common use of non-standard meters which cannot be adequately repaired by WAJ. Also, the WAJ repair shop places high priority on industrial meter repair as a high charge is paid by industrial water users. Improvement and upgrading of the AZB metering system is needed, including establishment of an adequate meter repair and maintenance system, standardization of meters, strengthening of the monitoring system, improved data reporting and management, and water users' education and increased awareness. Such a program is estimated to cost JD386,000 and would benefit from support through a Groundwater Management Fund.

Information Management. The Oracle-based Management Information System (MIS) in the MWI has most data needed for adequate monitoring of the basin, except the well license information. This important information was partly tabulated electronically on EXCEL sheets during the project. This data transformation should be completed and entered into the MWI's MIS.

Upgrade of Surface and Groundwater Monitoring Networks. The surface water monitoring network appears adequate for the purposes of implementing the plan, but the groundwater monitoring network needs extensive rehabilitation, especially in the North-Eastern area, including the drilling of two groundwater monitoring wells in the North-Eastern Badia.

Augmentation of Supply through Brackish Water Resources Development. The brackish water study estimated that only 1.2 MCM/year of brackish springs water could be readily developed for M&I supply, in addition to approximately 15-30 MCM/year of brackish groundwater in the Basin. A detailed investigation is needed to verify and confirm the locations of exploration boreholes, to review the cost of wells, and to identify suitable means of brine disposal.

Augmentation of Supply through Run-Off Recharge and Water Harvesting. There is much farmer and professional interest in these augmentation schemes, although many have appeared to be unsuccessful in the AZB. These schemes could reduce downstream surface storage in KTR, but would not affect the hydrology given their insignificance compared to the existing 100% levels of overabstraction. However, pilot projects for small run-off harvesting schemes, and for a pilot recharge project already designed for Wadi Madoneh should be considered.

Augmentation of Supply through Treated Wastewater Recharge. The WRPS recharge study (MWI/ARD. 2001g. "Options for Artificial Groundwater Recharge with Reclaimed Water in the AZB and Jordan Valley") identified recharge infiltration sites in the Hallabat area, but such recharge is generally felt to be unacceptable due to the use of potable water wells in the area.

Water Users' Education and Awareness. As a result of the needs expressed by farmers during the Rapid Appraisal study, an agricultural water use educational and awareness program is recommended, preferably in conjunction with an irrigation advisory service. The program should include irrigation efficiency and agricultural water use under scarcity, introduction to water laws and regulations, and youth education on water use in the agricultural sector.

Capacity Building in the MWI. Priorities for capacity-building for implementation of the plan are additional remote sensing training, including establishing a GIS/RS unit in the MWI; strengthening private water use monitoring capability; and strengthening data analysis.

4. PLAN FOR MANAGING WATER REUSE IN THE AMMAN-ZARQA BASIN AND THE JORDAN VALLEY

4.1 Activities

The activities of the MWI/ARD Water Reuse Team were largely focused on developing the water reuse management action plan for the Amman-Zarqa Highlands (MWI/ARD. 2001m. "Plan for Managing Water Reuse in the Amman-Zarqa Basin and the Jordan Valley", 12 July, 2001) through a series of technical studies and consultation/review with stakeholders. The sequencing of the main activities implemented to develop the plan is explained in the second-year workplan (MWI/ARD, Annual Workplan: August, 2000 – August, 2001) and is summarized in Appendix 3. The background reports of the technical studies, and the plan itself, are referenced in Appendix 4.

The team initially concentrated on characterizing present and future reclaimed water resources (MWI/ARD. 2001d. "Characterization of Wastewater Effluent in the Amman-Zarqa Basin."); reviewing water reuse laws, standards and processes (MWI/ARD. 2001c. "Standards, Regulations & Legislation for Water Reuse in Jordan"; and Nazzal, Y. K., M. Mansour, M. Al Najjar, P. G. McCornick. 2000. "Wastewater Reuse Law and Standards in the Kingdom of Jordan."); and assessing the needs for monitoring and information management (MWI/ARD. 2000c. "Monitoring & Information Management Pertaining to Water Reuse in Jordan."). These, and subsequent technical studies, were updated as more information became available through the program period.

With the assistance of stakeholders, the team then identified and assessed the potential options for water reuse, beginning with AZB Highlands options: MWI/ARD. 2000b. "Pre-Feasibility Study – Water Reuse for Agriculture and/or Forestry in the Amman-Zarqa Highlands"; and Shaner, W. W. 2000. "Economics Study for Water Reuse for Agriculture and/or Forestry in the Amman-Zarqa Highlands: Technical Report.". The Jordan Valley options were then investigated (MWI/ARD. 2001e. "Water Reuse Options in the Jordan Valley"; and Shaner, W. W. 2001. "Economics Study for Managing Water Reuse in the Amman-Zarqa Basin & the Jordan Valley."), followed by the other areas for potential options (MWI/ARD. 2001b. "Water Reuse in Wadi Zarqa & from Other Amman-Zarqa Sources."; MWI/ARD. 2001h. "Identification and Pre-Feasibility Analysis on Non-Agricultural Reuse Options for Reclaimed Wastewater from As Samra."; and MWI/ARD. 2001g. "Options for Artificial Groundwater Recharge with Reclaimed Water in the Amman-Zarqa Basin & Jordan Valley.".

Important technical studies which supported the analysis of the individual options, as well as indicating more general actions needed to support these options, included assessment of impacts of reclaimed water on plants and soils (Grattan, S. R. 2000. "Impact of Increasing Supplies of Reclaimed Water on Crops, Soils and Irrigation Management in the Jordan Valley"); economic, financial, and marketing assessments (the above economics reports as well as: Fitch, J. B., and A. Jaberin. 2001. "Marketing Jordanian Vegetables and Fruits in the Context of Irrigation with Reclaimed Water."); and pollution assessments (MWI/ARD. 2001i. "Controlling Harmful Discharges to Wadi Zarqa.".

The analysis of practical combinations of options (scenarios) was initiated early in the program, and provided the necessary technical background for selection of priority options, and then for the analysis of the water reuse system as a whole. These analyses centered on modeling of conveyance, storage and blending (MWI/ARD. 2001a. "Storage, Conveyance & Blending for Water Reuse in the Amman-Zarqa Basin".; and MWI/ARD. 2001f. "Storage, Conveyance &

Blending & Analysis of Scenarios for Water Reuse in the Amman-Zarqa Basin."), and the economics analyses described in the above economics reports.

The results of all of these studies were integrated into an interim report in April, 2001, and following presentations and reviews by the Team and stakeholders, and the completion of the remaining technical studies, a first draft plan was completed in June, 2001, and – after further review – finalized as the July 12, 2001, water reuse management plan.

4.2 Results

Characterization of Reclaimed Water Resources

The Hashemite Kingdom of Jordan has a critical shortage of water resources. Water use per capita is among the lowest in the world, and the urban population continues to grow, with increasing water demand and, subsequently, increased volumes of wastewater. The majority of the treated wastewater is already reused indirectly in agriculture. As such, reclaimed water has become a major component of the national water budget, particularly in the densely populated Amman–Zarqa Basin (AZB) and Jordan Valley (JV). With the supply of freshwater being very limited and the demand expected to continue to increase, it is vital that the anticipated increases in reclaimed water be managed to meet, at least in part, national and regional demands.

The volume of reclaimed water available in the AZB is expected to grow from approximately 61 MCM/year in 2000 to almost 180 MCM by the end of the planning period, 2025. Over 90% of this will originate from the As Samra facilities, which include the rehabilitation of the existing As Samra wastewater treatment plant (WWTP) and the planned Zarqa WWTP downstream.

The quality of the reclaimed water is expected to improve with the implementation of the new facilities at As Samra. However, of the main constituents now of concern in irrigated agriculture in the AZB and JV - salts (specifically chlorides), microbiological contamination, and nitrogen (at sensitive growth stages of certain crops) - only nitrogen will be significantly reduced at point of use. The improvements at As Samra will reduce the microbiological contamination, but other secondary sources will continue to significantly contaminate the water in wadi Zarqa.

From the available data, the levels of trace elements and heavy metals in the effluent are lower than those specified by the relevant Jordanian standards, which, with the exception of zinc and boron, are as stringent as the United States Environmental Protection Agency's water reuse guidelines (EPA, 1992). Anticipated growth in industrial development within the AZB could increase the levels of harmful constituents in the wastewater.

Objectives of the Water Reuse Management Plan

The key policy objectives of the water reuse management plan are to use reclaimed water, where practical, to exchange for present and future uses of freshwater; and to maximize the returns from the reclaimed water resource. In addition, the plan considered other requirements such as protecting the public, conserving resources (water, soils/land, natural vegetation, etc.), complying with international treaties, and ensuring environmentally sound practices.

Water Reuse Management Options

Other than using reclaimed water for intimate domestic purposes, which was not considered viable because of sociological/psychological public acceptance issues, a broad range of options

was considered: commercial irrigation (agriculture, ornamental nurseries, and forestry); municipal (landscape, recreational, and residential); industrial; and others such as hydropower, artificial groundwater recharge, meeting international treaties, and environmental enhancement.

The Highlands, Wadi Zarqa, and the JV areas were each examined to determine which options were practical and at what scale. The planning process ensured that potential options were not rejected without careful consideration. Also, the process was iterative, adding in variations of options as investigations revealed additional opportunities for using reclaimed water.

Detailed investigations (pre-feasibility level studies) were conducted on potential options. Early iterations determined that pumping and conveying reclaimed water from As Samra to the highlands for commercial irrigation were not economically viable, and could be justified only where it was to be exchanged for present groundwater use. In addition, although sites for artificial groundwater recharge appear technically feasible in the highlands, the importance of the underlying aquifer makes it unsuitable for consideration in the planning time frame (up to the year 2025). Artificial groundwater recharge in the JV was found to have merit as a more drought-resistant alternative to surface storage.

From these initial investigations, seven priority options, presented in the attached Summary Table, were identified and assessed.

Exchange with groundwater in the Dhuleil–Hallabat area in the AZB Highlands. This option would deliver reclaimed water via pipeline to an area 14 km east of As Samra in order to exchange with present groundwater use within the existing Dhuleil project and individual farms in the Dhuleil and Hallabat area. This option would provide approximately 9.5 MCM (2.5 MCM to the Dhuleil project and 7.0 MCM to surrounding farms) of water/year, freeing up an equivalent quantity of groundwater. The quality of the groundwater ranges from 650 to 2,500 mg/l, which, if it were to be used for municipal supplies, would need desalination. The total capital cost is estimated to be JD35 million. Accounting for the need to desalinate some of the groundwater before it can be used for municipal supply, and allowing for an on-farm internal rate of return of 12%, the cost of providing 1 cubic meter of water by exchange with the reclaimed water is approximately 610 fils. Although this option would sustain irrigated agriculture in the Dhuleil-Hallabat area, a key concern is the potential impact on the underlying aquifer from the use of reclaimed water for irrigation, especially since this aquifer is an important source of water for municipal supply.

Exchange with groundwater, and meet future demands for industrial and municipal reuse, in the Hashemite–Zarqa area. This option consists of building a pipeline to convey reclaimed water 17 km to the Hashemite–Zarqa area where it would be stored and then delivered by spur lines to a few principal locations. The new power plant and the refinery would use the reclaimed water for industrial cooling, with an annual demand of 5.5 and 3.9 MCM, respectively. Lesser annual demand could come from the east Zarqa Planning Area (2.0 MCM), other industries (1.0 MCM), and the existing power plant (0.6 MCM). These amounts total 13.0 MCM, which would otherwise be pumped from the underlying aquifer. The capital cost of this option is estimated to be JD13 million. The total cost of providing 1 cubic meter of potable water by exchange with the reclaimed water is approximately 630 fils; however, this option is highly viable given the high value of water to industry, relative to that of agriculture. The fact that the new power station is required to use reclaimed water presents an opportunity to develop this broader reclaimed water option with minimal additional costs.

Water Reuse Management: Summary of Results from Options Assessment

OPTION	DESCRIPTION	DEMAND FOR RECLAIMED WATER	FRESHWATER CONSERVED		CAPITAL COSTS	ECONOMICS OF AGRICULTURE	INSTITUTIONAL RESPONSIBILITY	ADVANTAGES	DISADVANTAGES	IMPLEMENTATION ISSUES	PRIORITY
		MCM	Volume MCM	Cost fils/m^3	JD million						
Dhuleil–Hallabat Irrigation Network.	Exchange with groundwater for agriculture in the highlands.	9.5	9.5	610	35	Not viable unless exchange with groundwater considered.	WAJ. Water user organizations.	Conserves groundwater.	Risk of contaminating important aquifer.	Effluent quality. Ensure O&M costs available. Farmer involvement.	Moderate.
Industrial Reuse in Hashemite–Zarqa area.	Exchange with groundwater. Meet future demands.	13	13	630	13	Economics for use in industry are very good.	Industries. Private ownership of network. Government as facilitator.	Conserves groundwater. Power plant required to use reclaimed water.	Cooling system discharge could increase salt discharges to wadi.	Reliable effluent quality. New power plant by 2004. Stakeholder coordination vital.	High.
Wadi Zarqa.	Intensification of agriculture.	3.3	0	N/A	0	Good.	Farmers.	Low cost.	Health risk. No freshwater conserved.	Cooperation from farmers on health risk.	
Karameh Directorate	Intensification/ expansion of agriculture.	40	0	N/A	4.2	Moderate net return JD3.5 million.	JVA. Farmers.	Low-cost. Infrastructure exists.	No freshwater conserved.	None.	High.
Middle Directorate	Intensification of agriculture.	6	0	N/A	0	Good. Net return JD2.2 million.	JVA. Farmers.	Very low cost.	No freshwater conserved.	None.	High.
Northern Directorate	Exchange with freshwater used for agriculture.	57	57	430	87	Break even.	JVA. Farmers.	Volume of water conserved. Sustain agriculture.	Changes to cropping pattern. Potential loss of market. Difficult to implement. Resistance by water users.	Decision needed. User cooperation. Technical support. Phase in.	High.
Minor WWTPs.	Expand/intensify agriculture in vicinity of plant.	6.6	2			Low to moderate.	WAJ. Farmers.	Could replace freshwater. Progressive projects.	Potential contamination of important aquifers. Urbanization.	Must be high-value crops. Wait until other options satisfied.	Low.

Intensification of irrigated agriculture in Wadi Zarqa, downstream of As Samra. In addition to the present use of reclaimed water in the wadi, if future market and regulatory conditions allow, farmers could irrigate, a further 3,000 dunums which was historically irrigated. This would require approximately 3.3 MCM of reclaimed water, and would be financed privately by those farmers who hold the pre-existing rights. Freshwater would not be conserved. The major issue is the continuing health risks to consumers of irrigating raw-eaten vegetables, especially given the high fecal coliform levels in the water supply.

Intensification and expansion of irrigated agriculture in the Karameh (Southern) Directorate of the Jordan Valley (Stage Offices 6, 9, and 10). Given the current and historic water shortages in this area, this option would use an additional 40 MCM/year of reclaimed water, allowing expansion onto 34,000 dunums, which already has physical infrastructure developed to farm-unit level, and intensification on a further 5,600 dunums, at a total capital cost of JD4.2 millions. No fresh water will be saved, as the existing Kufrein water supply is not considered suitable for transfer to municipal use. This option is economically viable, with expected increases in net returns from this expansion and intensification of JD3.1 million after all costs have been accounted for. Improving the productivity of agriculture will require further development of the farmers' skills to effectively manage the water and deal with the quality aspects of the reclaimed water. The primary environmental concern is the potential contamination of the underlying groundwater by the use of reclaimed water for irrigation. However, the groundwater here is not a significant source of municipal supply, much of it being already more saline than the proposed irrigation water, and irrigation with reclaimed water is already practiced in the area.

Intensification of agriculture at Stage Offices 4, 5, and 8 of the Middle Directorate of the Jordan Valley. Given that present supplies of water are insufficient to meet demand, this option would provide an additional 6 MCM/year of reclaimed water to intensify production and expand the irrigated area by 6,000 dunums. Although there is some current use of freshwater from the KAC, the opportunity for exchange with reclaimed water is very limited, since it generally is available during high-flow months when the municipal demand is being met. Only minor investments would be needed, for some farm level structures and for farmer education, making this option highly economically viable, and relatively easy to implement, based on pre-existing rights that are not currently being fully met.

Exchange with surface water at Stage Office 3 of the Middle Directorate, and in the Northern Directorate (Stage Offices 1, 2, and 7) of the Jordan Valley. This option would require 57 MCM/year of reclaimed water to replace the same volume of existing freshwater supplies, requiring the construction and operation of a gravity pipeline that would carry reclaimed water from Wadi Zarqa downstream of the KTR to the upper reaches of the Northern Directorate. The capital investment required is estimated to be JD87 million, and if the option were to be developed in conjunction with the transfer of freshwater to domestic use, then the cost 430 fils for each m^3 of freshwater transferred and delivered to the Zai treatment plant. This is a technically and economically viable option if the value of freshwater transferred from irrigation to domestic use is included, and may be the best way to sustain irrigated agriculture in the Northern Directorate if the shortly-to-be-completed facility to transfer a further 45 MCM/year of freshwater from the Jordan Valley to the Highlands is used. The major disadvantages are strong farmer opposition, the need to substitute existing crops with more salt-tolerant crops and other needed farm-level adjustments, and the high capital cost.

Development of commercial irrigation at the minor Wastewater Treatment Plants (MWWTPs). These plants are located at Jerash (East), Abu Naseir, and Baq'a, with an additional facility planned for Jerash (West). Current reuse is 0.6 MCM/year, but this could rise by a further 6.6 MCM/year by the year 2025,a major effort was made in the Baq'a area, where 2 MCM/year of freshwater could be conserved. Although costs for development would be moderate, there is potential for contamination of important aquifers, and it would be difficult for farmers to compete with the Jordan Valley options.

Water Reuse Management Scenarios

The identified options, for use of the anticipated increased supplies of reclaimed water available form the AZB, were grouped into two alternative scenarios, based on the existing rights of water users, and explicit comparisons between the options based on the objectives of the management plan.

- Existing obligations are assumed to take priority, as follows:
  - existing uses of reclaimed water will continue to be met at least at the same levels in the Middle Directorate and stage office 6 of the Karameh Directorate of the Jordan Valley, and in Wadi Zarqa.
  - fully meet the needs of preexisting allocations that have not yet been met. These are the options to allocate further reclaimed water to the Middle Directorate, Wadi Zarqa, and the Hashemite University. Except for the latter, these options will produce increased net returns with little investment. In the case of Wadi Zarqa, the projected increase in water consumption will occur if markets for irrigated produce improve. It is, therefore, prudent to include this in the scenario analysis.

- Comparison based on the objective of conserving freshwater:

Option	Capital Cost (JD)	Freshwater (MCM)	Cost (fils/m^3)
Northern Directorate	87 million	57 million	430
Dhuleil-Hallabat	35 million	10 million	610
Industrial	13 million	13 million	630

- Comparison based on the objective of maximizing returns from the resource in agriculture (industrial uses are considered to have higher priority in general):

Option	Capital Cost (JD)	Reclaimed Water (MCM)	Net Revenues (JD)
Middle Directorate	0	6 million	2.2 million
Karameh Directorate	4.2 million	40 million	3 million
Northern Directorate	87 million	57 million	Break even
Highlands Agriculture			Not viable

If the Northern Directorate option is not considered, then the above analysis leads to the following, Scenario 1:

SCENARIO 1 Option	Year Fully Met	
	Reclaimed water supply as projected	Reclaimed water supply 15 % less than projected
Preexisting demands	2005	2006
Industrial (HL #1)	2006	2007
Karameh Directorate	2014	2019
Dhuleil–Hallabat	2015	2020
Other WWTPs	2016	2021

If the Northern Directorate is included in the management plan, then the above analysis leads to the following, Scenario 2:

SCENARIO 2 Option	Year Fully Met
	Supply as Projected
Preexisting demands	2005
Industrial	2006
Northern Directorate	2017
Karameh Directorate	2030
Dhuleil–Hallabat	-
Other WWTPs	-

These scenarios have been found to be technically and economically viable at pre-feasibility level.

Supporting Actions

A series of actions designed to support and sustain the implementation of the management options and scenarios were included in the water reuse management plan, as follows:

Improving On-Farm Water Management. The challenges facing irrigated agriculture in using this reclaimed water resource cannot be overemphasized. Although the reuse management options were shown to be technically and economically feasible, and the existence of a few farmers with very high levels of management expertise in the Jordan Valley, to sustain irrigated agriculture in the future requires that the majority of farmers' skills and knowledge be significantly improved. Farmers must understand how to effectively manage water for their specific situation and be able to access information on existing and emerging issues concerning water quality. To develop, maintain, and disseminate this information requires an effective extension service and applied research capability that not only considers management of water quantity, but also water quality's relationship with the soil and crops. The specific objectives of improving on-farm water management would be to improve agricultural returns, to ensure sustainability, and to reduce risks associated with the microbiological contamination of the water in Wadi Zarqa. The required actions are enhancements and integration of the extension and applied research services such that they focus on solving the actual problems faced by the farmers, particularly concerning the water quality. The lack of coordination and cooperation between the relevant extension and research institutions is perhaps the biggest constraint in this area.

Strengthening of Monitoring and Information Management. Although the level of monitoring in the AZB and Jordan Valley is generally adequate, the data are being gathered by a number of different agencies which find it difficult to share and disseminate the relevant information. Changes are needed in the way water quality data are collected, managed, and routed to the MWI and other agencies with an interest in water quality data and information. The objectives would be to improve efficiency, to standardize methods of monitoring and information management, and to provide a mechanism for the different agencies responsible for monitoring water quality to work together, revise and/or better coordinate efforts, and develop and implement a countrywide monitoring plan.

Marketing Development. The current uncertainty about the safety of fresh vegetables grown in Jordan through direct and indirect use of reclaimed water presents a serious marketing problem. The strict enforcement of the unauthorized use of reclaimed water in Wadi Zarqa is a prerequisite to improving the marketing uncertainty. Several additional measures are required to improve the safety and quality of Jordan's vegetables, including: Clarify the regulatory responsibility for food safety in fresh vegetables; Improve management and availability of information on water quality and food safety; Initiate applied research to clarify the relationship between water quality and the sanitary condition of fresh vegetables in Jordan; Establish microbiological testing of fresh vegetables to check for pathogens; Incorporate practices for safe use of irrigation water in Good Agricultural Practices (GAPs) for production of fresh vegetables and fruits and promote their use; and promote the establishment of a grower certification system and/or accredited product marketing organizations that meet international standards.

Risk Reduction in Wadi Zarqa. Concurrent to the efforts to improve the quality of effluent from the WWTPs and reduce the microbiological contamination from secondary sources, an initiative to work with the farm community to further alleviate the health risks to farm workers and the general public through the use of reclaimed water needs to be undertaken. This initiative, which must be separated from attempts to enforce the ban on growing raw-eaten vegetables, should attempt to reduce the production of all raw-eaten vegetables or fruits whose edible parts may contact the irrigation water in from all Wadi Zarqa sources, and support a training program for farm workers to minimize their exposure to pathogens associated with irrigation.

Controlling Secondary Fecal Contamination Sources. Separate from a standard monitoring plan discussed above, an aggressive short-term monitoring effort is recommended to control primary and secondary sources of fecal contamination in the AZB, and develop a plan to remove them. Once secondary sources of contamination have been located, corrective measures need to be taken to eliminate the sources of contamination and to patrol the basin to make sure potential contaminant sources are avoided in the future. Citations should be issued to individuals, groups, or operations that contaminate or that can potentially contaminate the irrigation water supply.

Enhancement of the Jordanian Standards and Guidelines for Water Reuse. The existing standards should be revised as a result of their many deficiencies, including the fact that current standards for water reuse specifically prohibit unrestricted use of reclaimed water for irrigation of vegetable crops. A three-tiered set of criteria is recommended: the first tier would encompass only the legally enforceable water reclamation standards, primarily aimed at protecting the public health and the workers' health, to be accomplished through regulation of parameters that (1) ensure optimal performance of the WWTP, (2) indicate microbiological safety of reclaimed water, and (3) can be controlled at the WWTP; a second tier of criteria is aimed at protection of the soil and crop yields, with parameters dealing with these concerns being assigned limits as "guidelines" (not legally enforceable standards); and a third tier of criteria which addresses a

relatively new concern, called “emerging” contaminants, including synthetic organic compounds, various pharmaceutical products, and endocrine disruptors, which are of greatest concern in the drinking water supply. Two sets of separate standards, one for treatment plant discharge requirements and another for water reclamation and reuse, should be developed. It is recommended to limit the scope of legally regulated water reuse standards to the primarily public health parameters, and provide for requirements and prohibitions that protect the health of field workers and the general public. These requirements should be legally enforceable, providing for measured and appropriate penalties for violations.

Controlling Hazardous Discharges to Sewers and Wadis. Although current industrial discharges appear to not significantly impact reuse potential, the projected rapid urbanization and industrialization of the upper AZB catchment is expected to substantially increase industrial mass discharge. Therefore, more stringent regulations and enforcement are necessary to protect the reclaimed water from contaminants that could prevent it from being used for its intended reuse application. Many specific actions that should be taken are presented in the management plan.

5. CAPACITY-BUILDING FOR SUSTAINING WATER RESOURCE POLICY IMPLEMENTATION

Using as a basis the specific tasks related to development and support for the groundwater and water reuse management plans, the following efforts were made to support the MWI in building up its capacity to sustain water policy implementation activities in general: MWI staff training, assistance with management of data and information, and stakeholder participation in the planning and implementation process. The formal training or workshop activities associated with these efforts are detailed in Appendix 5.

Capacity-building assistance for monitoring and data management included numerous inputs by short-term technical assistants and material support such as the rehabilitation of seven Static Water Level monitoring wells, and construction of a surface gauging station, in the AZB highlands.

In addition to the principal capacity-building activities arising from the integrated efforts of the MWI/ARD groundwater and water reuse teams in developing the groundwater and water reuse management plans, the program implemented three programs of participation of MWI staff at international meetings, two intensive technical training programs at the MWI, numerous stakeholder meetings/workshops, and a program of training and technical support to the new Laboratory Information Management System at the WAJ Central Laboratory.

5.1 Participation of MWI Staff at International Meetings

The AQUA 2000 Conference

Eng. Fayez Bataineh, Eng. Yasser Nazzal, Ms. Maysoon Zubi, Eng. Mohamed Najjar, and Dr. Peter McCornick traveled to Abu Dhabi in April, 2000, to participate in the AQUA 2000 Conference. The participants presented and discussed their paper (Nazzal, Y. K., M. Mansour, M. Al Najjar, P. G. McCornick. 2000. "Wastewater Reuse Law and Standards in the Kingdom of Jordan."), networked with practitioners of water reuse at all levels, and participated in other sessions of the conference and in the workshop on water reuse.

The participants obtained valuable feedback on their paper, which was subsequently used as a basis for the reuse standards recommendations of the water reuse management plan, learned about alternative approaches to implementation of water reuse policies, gained and strengthened important international contacts, and strengthened their ability to cooperate as a MWI/ARD team.

Multi-purpose Visit to the Western United States, December, 2000

Eng. Edward Qunqar traveled to the Western United States in December, 2000, to participate in the National Groundwater Association Annual Conference, Las Vegas; the Fall Conference of the American Geophysical Union, San Francisco; and to implement site visits to groundwater and reclaimed water facilities in the Los Angeles area.

Eng. Qunqar undertook international networking, participated in the discussions of the conference theme "Groundwater: a transboundary, strategic and geopolitical resource", and reviewed policy implementation with practitioners in the groundwater and reclaimed water areas in California.

Regional Workshop on Water Reuse in the Middle East and North Africa

Eng. Yasser Nazzal traveled to Cairo, Egypt, in July, 2001, to participate with MWI and other colleagues in the Regional Workshop on Water Reuse in the Middle East and North Africa. Eng. Nazzal undertook international networking and participated in discussions of the latest developments in water reuse in the Middle East, of potential benefit to Jordan.

5.2 Formal Technical Training at MWI

Satellite image interpretation and analysis of changes in upland agriculture

Ten MWI staff were trained in satellite image interpretation and analysis of changes in upland agriculture, during a period of two weeks in October, 2000, at the MWI offices, as an integral part of the groundwater management plan task to monitor and estimate cropped areas in the AZB. The instructor was Dr. Lynnette Wood, in association with Nidal H. Saliba of InfoGraph, and assisted by Eng. Tamim Abodaqa.

The ten MWI staff gained an understanding of the basics of remote sensing and image classification, received the certificate of successful completion of the ER Mapper 6.1 Training Course, and completed a preliminary classification of the vegetation of the North-East Highlands of the Amman-Zarqa Basin for August, 1999.

Decision-makers gained insights into practical applications of the technique for water resources planning and management, the limitations, and the logistic and capacity-building required to fully make use of this new technology.

These results show that remote sensing could be used as a potential monitoring tool for the irrigated cropped area, and therefore for changes in water abstraction, once the analytical procedures have been further refined and validated.

Groundwater Modeling System (GMS) Training

Ten MWI and WAJ staff were trained in the use of Groundwater Modeling System (GMS) and FEMWATER software, during a period of two weeks in January, 2001, at the MWI offices, as an integral part of the groundwater management plan task to estimate past and future impacts of alternative groundwater management scenarios in the AZB.

The instructor was Dr. Yahia Majali, assisted by MWI/ARD staff and InfoGraph. Participants learned how the conceptual model for the AZB was specified, and how the various future scenarios were being tested, gaining an appreciation for how this tool could be extended for further use in the AZB, and for applications to other Basins.

5.3 Stakeholder Participation

The capacity of the MWI and other stakeholders to collaborate on implementing water resource policies was improved through numerous formal and informal meetings between the MWI/ARD team and stakeholders, and through surveys of farmers in the Highlands of the AZB, the Wadi Zarqa and the Jordan Valley.

In developing the management plans, stakeholders were consulted from the earliest stages, stakeholders' suggestions and feedback were explicitly incorporated into planning, and

stakeholder groups were consulted. The most important stakeholder groups were the small groups of farmers and community leaders who met in late-2000 to review the results of the Rapid Appraisal Study of groundwater uses and users in the AZB Highlands, and the two large, formal stakeholder meetings of November, 1999, and June, 2001.

Water Policy Implementation Planning workshop, November, 1999

More than thirty MWI, WAJ and JVA staff met for a one-day Water Policy Implementation Planning workshop in November, 1999, at the Marriott Hotel, Amman. The meeting was facilitated by MWI/ARD staff. Ministry, JVA and WAJ staff provided their input into the draft workplan for the project, and discussed the place of the project within the context of priority needs for the water sector in Jordan. This led to a common understanding of the purposes and intended outputs of the project.

Water Policy Implementation Stakeholder Meeting, June, 2001

More than eighty MWI staff and stakeholders met at a one-day Stakeholder Meeting on June 11, 2001, at the Dead Sea Movenpick Hotel, to review the draft groundwater and water reuse management plans. The stakeholders included community leaders, farmers, other users, and staff of local and national government, and independent institutions. Stakeholders provided collective feedback on the draft plans, and the interactions strengthened rapport between the main parties who would be expected to participate in finalizing and implementing the plans.

5.4 Assistance for the Laboratory Information Management System (LIMS) at the WAJ Central Laboratory.

Both MWI and USAID specifically requested the MWI/ARD Water Resource Policy Support activity to assist with sustaining the laboratory information management system (LIMS) purchased by WAJ with the support of – but after the completion of – a previous project. The effective operation of the MWI water quality laboratories is essential for good management of policy implementation.

It was felt that LIMS had not yet been fully established and was not yet sustainable within the MWI. The objectives of further support were to ensure that the LIMS was effectively installed and that the WAJ would be able to effectively and sustainably operate and maintain the system

The project has assisted this process at the WAJ Central Laboratory by:

- purchase of 2 computers for the lab to support LIMS
- training of WAJ staff (Samer Mukattash and Mohammad Akkoub) in Oracle
- purchase of a LIMS support and maintenance plan from the Applera Corporation business "Applied Biosystems"
- purchase of a Spectrophotometer with associated equipment and reagents
- assistance with repairs to the Packard liquid scintillation counter
- purchase of LIMS support accessories such as an external modem and phone line for the WAJ LIMS server
- technical assistance for initial testing of LIMS and conversion of data inputting from the FoxPro to the Oracle-based systems (Zawati, Hala Adel. "Support to LIMS at the WAJ Central Lab.". July, 2001)
- technical assistance by Howard Wong for Migration of Water quality data from WAJ/RSS to MWI WIS (MWI/ARD. 2000k. "Information Management – Migration of Water Quality Data from WAJ and RSS to MWI WIS.").

6. CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of each of the activities implemented during the course of this project are detailed in the relevant project reports. The objective of this summary is to provide more general, over-arching conclusions and recommendations.

The groundwater and water reuse management plans present practical and implementable solutions to some of the important issues currently facing water resource decision-makers and water users in Jordan. The plans, along with their supporting technical documents, represent a secure basis on which to proceed with feasibility-level studies for any of the selected options. The plans, which present prioritized options, and clearly demonstrate the technical and economic viability of each, can be used by decision-makers at all levels. It is recommended that the technical and collaborative momentum generated by project activities be maintained through timely decision-making at Ministry level to implement priority management options. Any consequent feasibility-level planning should include the key stakeholders who have been very productively involved in the planning process to date.

The program achieved its objectives of supporting the implementation of crucial water resource policies through a collaborative and highly-technical process, focusing a wide range of technical material and personnel on the management plans which can now be used as powerful tools for implementation. This process can be readily applied to similar water resource concerns, as significant efforts were made during the program to improve the long-term basis for other policy implementation activities through general support activities.

The operational flexibility of the program, particularly through the process of developing the two annual workplans which allowed specific changes in program design/emphasis, ensured that resources were focused on the priority results, taking account of the constraints encountered and utilizing the knowledge acquired by the MWI/ARD team during implementation. It was particularly important to gradually increase the participative profile of stakeholders through the life of the program, from initial exploratory contacts with individuals to the later larger groupings, culminating in the June, 2001, meeting of more than eighty stakeholders; this process was driven by the increasing trust built up within the MWI/ARD team and between the team and stakeholders, and also by the increased clarity of the plans themselves as more information became available on the management options. The excellent collaboration and rapport which developed between MWI and ARD staff was a particularly key ingredient in the program's success.

The contributions of a wide range of stakeholders, covering the range of involvement from the Ministers of Water and Irrigation to the farmers, were crucial to ensuring that the management plans are practical and reasonable. Stakeholders have made invaluable contributions to the identification and screening of potential management options, and to the detailed assessment of prioritized options. The rapport that has been developed between government staff and the other main stakeholders should be maintained and strengthened through appropriate high-level leadership. The excellent level of participation of stakeholders in key program activities such as the Rapid Appraisal of groundwater users in the AZB Highlands was considered unlikely at the beginning of the program, and reflects the interest of farmers and community leaders in future decisions related to water resource management.

Some of the main recommendations of the MWI/ARD groundwater management team were:

- Form the Groundwater Management Consultative Committee (GMCC), which is strongly supported by stakeholders, to support the implementation of the groundwater management plan.
- Establish and institute the Groundwater Management Fund (GMF), which is strongly supported by stakeholders.
- Establish alternative activities and projects for those who opt for well buy out.
- Enforce interdiction of illegal drilling; and amendment of water use and management-related laws and regulations to cover groundwater management actions such as the GMCC, GMF, IAS, exchange of groundwater with treated wastewater etc.
- Implement institutional reform based on integrated basin level management, with stakeholder participation, especially water users.
- Implement the suggested plan to improve the reliability and accuracy of the metering of irrigation groundwater abstraction.
- Implement recommendations of the MWI/ARD study on the rehabilitation of the groundwater and wadi flow monitoring networks.
- Complete compilation of well license data and transfer it to the MWI Water Information Database.
- Support capacity building in data analysis and interpretation related to water resources management.
- Establish a GIS/Remote sensing Unit to support monitoring of the implementation of the groundwater management action plan.
- Support agricultural water user education and public awareness, preferably in conjunction with an IAS.

Some of the main recommendations of the MWI/ARD water reuse team were:

- An early decision on use of reclaimed water in the Northern Directorate is needed. This is a very attractive opportunity, but has major political, socio-economic and technical consequences.
- Implement a detailed feasibility study on the Industrial and Municipal Reuse Option in the Hashemite-Zarqa area. This should be done in coordination with the existing major water users in the area, and the representatives for the planned power plant.
- Implement a major integrated extension and applied research program to support farmers in the Jordan Valley and Wadi Zarqa to improve on-farm water management, especially to address the water quality related issues. Also, in cooperation with the farmers in Wadi Zarqa, further reduce the health risk of irrigating raw-eaten crops with microbiologically contaminated water. The applied research should develop reclaimed water management guidelines for inclusion in Good Agricultural Practices (GAPs).
- Enhance information management, especially with regards to information on water quality and making it available to farmers.
- Introduce regular monitoring of water quality and reporting of results to enable farmers to maintain soil and crop health. Investigate the linkage between reclaimed water and microbiological contamination on crops, if any.
- Implement a basin-wide study to determine the sources of secondary fecal contamination and develop controlling measures.
- Using the framework developed under this component, continue the development of enhanced Jordanian standards and guidelines for water reuse
- Support stronger control of hazardous discharges to sewers and wadis.

APPENDIX 1. PROJECT STAFF

Name	Position	Start date	End date	Main activities
INTERNATIONAL LONG-TERM STAFF				
Mohamed Chebaane	Hydrologic Cycle Monitoring and Modeling Spec.	1-Sep-99	15-jul-01	Coordinated, managed and provided technical inputs as groundwater component team leader, resulting in the development of a groundwater management plan
Gordon Stanger	Wastewater Reuse Spec.	18-Sep-99	31-Dec-99	Managed project start-up and initial activities of the water reuse component
Steve Luxton	Chief of Party/Water Demand Spec.	18-Oct-99	8-Jun-00	Provided overall leadership for the initial activities of the program, and technical inputs to the water reuse component
Peter McCornick	Wastewater Reuse Spec.	22-Feb-00	13-jul-01	Coordinated, managed and provided technical inputs as water reuse component team leader, resulting in the development of a water reuse management plan
Tom Cusack	Chief of Party/Resource Economist	10-Apr-00	8-Aug-01	Provided overall management and administrative leadership and supervision, and technical and administrative inputs

Name	Position	Start date	End date	Main activities
INTERNATIONAL SHORT-TERM STAFF				
Robert Yoder	Irrigation Spec.	17-Sep-99	24-Sep-99	Managed project start-up
Kim Glenn	Information/Data Management Spec.	11-Oct-99	21-Oct-99	Assessed MWI/ARD MIS needs
Robert Yoder	Irrigation Spec.	3-Nov-99	19-Nov-99	Assisted with start-up workshop
Lynnette Wood	Confer./workshop Facilitator	4-Nov-99	6-Nov-99	Assisted with start-up workshop
Lynnette Wood	Modeling/remote sensing Spec.	7-Nov-99	18-Nov-99	Assessed the remote sensing needs of MWI/ARD
Robert Yoder	Irrigation Spec.	4-Jan-00	28-Jan-00	Assisted with preparation of the first year workplan
Kim Glenn	Information/Data Management Spec.	21-Feb-00	5-Mar-00	Assessed the MWI's capability for producing a technical bulletin
Andrew Alspach	GIS/Statistics Spec.	24-Feb-00	24-Mar-00	Assessed and provided GIS needs for the Rapid Appraisal of groundwater use in the AZB, and for other uses
Robert Yoder	Acting COP	5-Mar-00	18-Apr-00	Implemented the transfer of project management
Sam Johnson	Agro-socio-economist	9-Mar-00	24-Mar-00	Assisted with planning of the Rapid Appraisal of groundwater use in the AZB
Bahman Sheikh	Water Reuse/Standards Spec.	6-Apr-00	26-Apr-00	Assessed water reuse in Jordan with MWI, ARD, and other staff, and prepared six technical memoranda on water reuse in Jordan
Andrew Alspach	GIS/Statistics Spec.	4-Jun-00	30-Jun-00	Improved access of MWI/ARD to the MWI and other databases, provided GIS products based on this access, and prepared for the upcoming remote sensing activity
Garry Grabow	Water quality Spec. – irrigation	13-Jun-00	1-Jul-00	Drafted a simulation model of storage-conveyance-blending of reclaimed water in the AZB and Jordan Valley
Blaine Hanson	Crop Water Requirements Spec.	110-Aug-00	2-Sep-00	Assessed the potential for an irrigation advisory service program in the AZB Highlands
Lynnette Wood	Modeling/remote sensing Spec.	18-Sep-00	29-Oct-00	Trained MWI staff in remote sensing and made image classifications for land use in the AZB
Steve Grattan	Irrigation Spec.	2-Oct-00	17-Oct-00	Assessed crop/soil/water management strategies for use of reclaimed water in the Jordan Valley
Andrew Alspach	GIS/Statistics Spec.	6-Oct-00	17-Nov-00	Researched, developed and presented a potential monitoring and information management framework for the MWI's water reuse data
Bill Shaner	Agro-socio-economist	2-Nov-00	24-Nov-00	Completed economic and financial analyses of using reclaimed water in the AZB Highlands
Yahia Majali	Data management/modeling Spec.	09-Nov-00	31-Jan-01	Modeled the hydrogeology of the AZB under various future abstraction scenarios

Name	Position	Start date	End date	Main activities
Garry Grabow	Water quality Spec. – irrigation	20-Nov-00	11-Dec-00	Drafted a working paper describing initial results for the simulation model of storage-conveyance-blending of reclaimed water in the AZB and Jordan Valley
Robert Yoder	Irrigation Spec.	21-Nov-00	1-Dec-00	Assisted with contractual matters and personnel planning
Bahman Sheikh	Water Reuse/Standards Spec.	4-Jan-01	26-Jan-01	Prepared a draft document recommending specific standards, regulations and legislation for water reuse in Jordan
Jim Fitch	Water Sector Policy Support Spec.	13-Jan-01	20-Mar-01	Assessed the economic impacts of implementing groundwater management options which would reduce abstraction for irrigation
Rick Allen	Crop Water Requirements Spec.	15-Feb-01	23-Feb-01	Updated the MWI crop water requirement and net irrigation requirement calculations
Garry Grabow	Water quality Spec. – irrigation	12-Mar-01	31-Mar-01	Completed the simulation of storage-conveyance-blending of reclaimed water for alternative scenarios in the AZB and Jordan Valley
Robert Yoder	Irrigation Spec.	12-Mar-01	23-Mar-01	Assisted with the project close-out plan and the final contract modification
Ken Edworthy	Reuse/Groundwater recharge Spec.	13-Mar-01	2-Apr-01	Assessed the potential for artificial recharge of wastewater in the AZB and Jordan Valley
Howard Wong	Brackish Water specialist	15-Mar-01	26-Apr-01	Assessed the potential use of brackish water for M&I supply in the AZB
Barnes Bierck	Water Reuse/Harmful Discharge Spec	18-Mar-01	29-Apr-01	Assessed the non-agricultural options for use of reclaimed water from the As Samra plant, and made recommendations for improved control of discharges to sewers and wadis
Bill Shaner	Agro-socio-economist	21-Apr-01	23-May-01	Assessed the economic viability of implementing fifteen options for use of reclaimed water in the AZB and the Jordan Valley
David Cone	engineer: Metering Spec.	20-Apr-01	11-May-01	Reviewed the current well metering program and developed a costed plan to improve its reliability and accuracy
Howard Wong	Chemist/Monitoring/Database Spec.	1-May-01	4-Jun-01	Assessed the compatibility of current standard analytical methods of WAJ and RSS, and made recommendations for improving data transfer
Bahman Sheikh	Water Reuse/Standards Spec.	14-May-01	28-May-01	Prepared a final document recommending specific standards, regulations and legislation for water reuse in Jordan
Steve Grattan	Irrigation Spec.	15-May-01	31-May-01	Completed the assessment of crop/soil management strategies needed to optimize use of reclaimed water in the Jordan Valley
Robert Yoder	Irrigation Spec.	29-May-01	13-Jun-01	Assisted with the stakeholder workshop and project close-out
Jim Fitch	Water Sector Policy Support Spec.	1-Jun-01	28-Jun-01	Evaluated crop marketing issues related to the use of reclaimed water
Howard Wong	Chemist/Monitoring/Database Spec.	05jun01	02aug01	Assisted with technical specifications for LIMS data transfers
Robert Yoder	Irrigation Spec.	24-Jul-01	8-Aug-01	Assisted with final project close-out

Name	Position	Start date	End date	Main activities
NATIONAL LONG-TERM TECHNICAL STAFF				
Hussein Hamdan	Network/Data Spec.	2-Oct-99	8-Aug-01	Assisted MWI/ARD in computer and network establishment and technical management
Suhair Jamal Hattar	Help Desk Administrator	2-Oct-99	23-Dec-99	Assisted MWI/ARD through providing Computer Help Desk services
Rana Mustafa	Help Desk Administrator	27-Feb-00	8-Aug-01	Assisted MWI/ARD through providing Computer Help Desk services
Tareq G. Al-Zabet	Groundwater Spec.	2-Apr-00	4-Sep-00	Assisted with the current and future hydrogeological assessments of the AZB
Lana Al-Naber	Engineer (groundwater)	11-Apr-00	8-Aug-01	Assisted with the comprehensive assessment and documentation of groundwater management options in the AZB, and with the detailed analysis of current uses and users of groundwater in the AZB
Tamim Abodaqa	GIS Spec.	22-May-00	8-Aug-01	Assisted with all GIS activities, related operations, and remote sensing techniques and training
Ramzi Sabella	Engineer (wastewater)	7-Jun-00	31-May-01	Assisted with the comprehensive assessment and documentation of water reuse management options in the AZB and Jordan Valley, and with the detailed analysis of current uses and users of reclaimed water
Ahmed Abu Hijleh	Groundwater Spec.	24-Jun-00	31-Jul-01	Assisted with all fieldwork associated with the groundwater team, including improvements to the groundwater monitoring system, and data compilation and analysis
Nisreen Haddadin	Engineer (wastewater)	2-Jul-00	8-Aug-01	Assisted with the analysis, documentation, and reporting of the water reuse options
NATIONAL LONG-TERM SUPPORT STAFF				
Mustafa M. Mustaf	Senior Driver/Expeditor	2-Oct-99	8-Aug-01	Provided driver and expeditor services to staff
Yasmin Al-Tayyar	Senior Office Administrator	9-Oct-99	8-Aug-01	Managed and administered the ARD office
Sawsan Abu Hijleh	Secretary	20-Mar-00	12-Feb-01	Assisted with management and administration of the ARD office
Sabri Abu Sham	Driver/Expeditor	2-Apr-00	8-Aug-01	Provided driver and expeditor services to staff
Ghada Kayyali	Secretary	11-Feb-01	8-Aug-01	Assisted with management and administration of the ARD office

Name	Position	Start date	End date	Main activities
NATIONAL SHORT-TERM STAFF				
M. Abu Ajamieah	Groundwater/Surface Water Support Spec.	6-Feb-00	13-Apr-00	Assisted the groundwater team in compiling and outlining AZB groundwater abstraction, and aquifer and geological characteristics data
Ali Sober	Hardware Spec.	17-Feb-00	16-May-00	Assisted the MWI/ARD team, both managerially and technically, in installing the new MWI-wide data and communications network
M. Hisham Khalil	Wastewater Reuse Spec.	1-May-00	30-May-00	Assisted the water reuse team in reviewing previous Jordanian technical studies, and in the identification and initial characterization of potential water reuse schemes
Hani Rashid	Water Quality Spec. – Irrigation	5-Nov-00	15-Dec-00	Assisted with field studies of, and stakeholder participation for, reuse options in Wadi Zarqa
Kamel Radaydeh	Regulatory Spec.	5-Nov-00	11-Mar-01	Assisted the groundwater team to incorporate stakeholders into planning, and assess the legal/regulatory bases for groundwater management options
Amer Jabarin	Economic/Financial Analysis Spec.	11-Feb-01	31-May-01	Assisted the groundwater team in assessing the impacts on employment, demographics, income, and agribusiness, of implementing alternative management actions for reducing groundwater abstraction in the AZB
Hani Rashid	Water Quality Spec. – Irrigation	2-Mar-01	30-Jun-01	Assisted with field studies of, and stakeholder participation for, reuse options in Wadi Zarqa and the Jordan Valley
Kamel Radaydeh	Water Sector Policy Support Spec.	12-Mar-01	31-Jul-01	Assisted the groundwater team to fully incorporate users into planning of practical options, to verify economic and technical data, to assess the metering system, and to assess brackish water development potential
Bashaar Amerry	Industrial Wastewater Treatment Spec.	2-Apr-01	31-Jul-01	Assisted the water reuse team on studies of non-irrigated reuse options in the AZB, and of harmful discharges to sewers
Amer Jabarin	Economic/Financial Analysis Spec.	1-Jun-01	30-Jun-01	Assisted the groundwater team in assessing the impacts on markets and exports of implementing alternative management actions for reducing groundwater abstraction in the AZB
Hala Zawati	Information/Computer Training Spec.	3-Jun-01	31-Jul-01	Assisted WAJ Central Lab to operationalize LIMS

APPENDIX 4

LIST OF DOCUMENTS

Fitch, J.B., "**Curtailment of Groundwater Use for Irrigated Agriculture in the Amman–Zarqa Basin Highlands: An Economic Analysis**," Water Resource Policy Support, MWI/ARD, Ministry of Water and Irrigation, March 29, 2001.

Fitch, J. B., and A. Jaberin. 2001. **Marketing Jordanian Vegetables and Fruits in the Context of Irrigation with Reclaimed Water**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

Grattan, S. R. 2000. **Impact of Increasing Supplies of Reclaimed Water on Crops, Soils and Irrigation Management in the Jordan Valley: Technical Report.** Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan

Hanson, R. Blane, "**Technical Report: Irrigation Advisory Services Program in the Highlands Area**," Water Resource Policy Support, MWI/ARD, Ministry of Water and Irrigation, August 31 , 2000.

Jabbarin, Amer, "**Curtailment of Groundwater Use for Irrigated Agriculture in the Amman–Zarqa Basin Highlands: A Socio-Economic Analysis**," Water Resource Policy Support, MWI/ARD, Ministry of Water and Irrigation, April , 2001.

Jabbarin, Amer, "**Curtailment of Groundwater Use for Irrigated Agriculture in the Amman–Zarqa Basin Highlands: An Agricultural Marketing Analysis**," Water Resource Policy Support, MWI/ARD, Ministry of Water and Irrigation, June, 2001.

MWI/ARD, "**Task Order Work Plan**", Water Resource Policy Support, MWI/ARD, Ministry of Water and Irrigation, January, 2000.

MWI/ARD, "**Planning of Rapid Appraisal of Groundwater Use in the Amman-Zarqa Basin**", Water Resource Policy Support, Ministry of Water and Irrigation, 18 April, 2000.

MWI/ARD, "**Outline Hydrogeology of the Amman–Zarqa Groundwater Basin**," Water Resource Policy Support, Ministry of Water and Irrigation, May, 2000.

MWI/ARD, "**Annual Progress Report**", Water Resource Policy Support, MWI/ARD, Ministry of Water and Irrigation, August, 2000.

MWI/ARD, "**Annual Workplan: August, 2000 – August, 2001**", Water Resource Policy Support, MWI/ARD, Ministry of Water and Irrigation, January, 2001.

MWI/ARD, "**Study of Groundwater Use and Users in the Northeastern Amman–Zarqa Basin Highlands**," Water Resource Policy Support, Ministry of Water and Irrigation, January, 2001.

MWI/ARD, "**Legal Assessment of the Groundwater Management Recommendations in the Amman–Zarqa Basin Highlands**," Water Resource Policy Support, Ministry of Water and Irrigation, April, 2001.

MWI/ARD, "**Hydrogeological Impacts of Overpumping and Assessment of Groundwater Management Options in the Amman-Zarqa Highlands**," Water Resource Policy Support, Ministry of Water and Irrigation, May, 2001.

MWI/ARD, "**Assessment of Potential Use of Brackish Water for M&I Supply in Amman–Zarqa Basin**," Water Resource Policy Support, Ministry of Water and Irrigation, May, 2001.

MWI/ARD, "**Groundwater Abstraction Metering and Monitoring, Amman–Zarqa Basin**," Water Resource Policy Support, Ministry of Water and Irrigation, June, 2001.

MWI/ARD, "**Rehabilitation and Upgrade the Groundwater and Wadi Flow Monitoring Networks, Amman–Zarqa Basin**," Water Resource Policy Support, Ministry of Water and Irrigation, June, 2001.

MWI/ARD, "**Report of a Stakeholders' Meeting**", Water Resource Policy Support, Ministry of Water and Irrigation, 11 June, 2001.

MWI/ARD, "**Groundwater Management Action Plan for the Amman-Zarqa Basin Highlands**", Water Resource Policy Support, Ministry of Water and Irrigation, 12 July, 2001.

MWI/ARD, "**Summary of the Water Resource Policy Support Activity: 09 August, 1999 – 08 August, 2001**", Water Resource Policy Support, Ministry of Water and Irrigation, August, 2001

MWI/ARD. 2001b. **Options for Water Reuse in Wadi Zarqa & from Other Amman-Zarqa Sources**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2001c. **Standards, Regulations & Legislation for Water Reuse in Jordan**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2001d. **Characterization of Wastewater Effluent in the Amman-Zarqa Basin**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2001e. **Water Reuse Options in the Jordan Valley**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2001f. **Storage, Conveyance & Blending & Analysis of Scenarios for Water Reuse in the Amman-Zarqa Basin**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2001g. **Options for Artificial Groundwater Recharge with Reclaimed Water in the Amman-Zarqa Basin & Jordan Valley**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2001h. **Identification and Pre-Feasibility Analysis on Non-Agricultural Reuse Options for Reclaimed Wastewater from As Samra**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2001i. **Controlling Harmful Discharges to the AZB**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2001k. **Information Management – Migration of Water Quality Data from WAJ and RSS to MWI WIS**. (Main report dated June, 2001, and supplementary report dated August, 2001). Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2001m. **Plan for Managing Water Reuse in the Amman-Zarqa Basin & the Jordan Valley**. 12 July, 2001. Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2000b. **Pre-Feasibility Study – Water Reuse for Agriculture and/or Forestry in the Amman-Zarqa Highlands**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

MWI/ARD. 2000c. **Monitoring & Information Management Pertaining to Water Reuse in Jordan**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

Nazzal, Y. K., M. Mansour, M. Al Najjar, P. G. McCornick. 2000. **Wastewater Reuse Law and Standards in the Kingdom of Jordan**. Presented at AQUA ABU DHABI 2000 "Wastewater Management for a Better Environment", Abu Dhabi.

Shaner, W. W. 2001. **Economics Study for Managing Water Reuse in the Amman-Zarqa Basin & the Jordan Valley**. Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

Shaner, W. W. 2000. **Economics Study for Water Reuse for Agriculture and/or Forestry in the Amman-Zarqa Highlands: Technical Report.** Water Reuse Component Working Paper, Water Policy Support, Ministry of Water and Irrigation, Amman, Jordan.

Wood, Lynnette, "**Remote Sensing Training and Landsat Image Classification**," Water Resource Policy Support, MWI/ARD, Ministry of Water and Irrigation, October, 2000.

Zawati, Hala Adel. "**Support to LIMS at the WAJ Central Lab**." Water Resource Policy Support, MWI/ARD, Ministry of Water and Irrigation, July, 2001

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APPENDIX 5.

SUMMARY OF FORMAL TRAINING/WORKSHOP ACTIVITIES

TRAINING	DATES	LOCATION	PARTICIPANTS	OUTPUTS/ACTIVITIES
Planning workshop, organized by MWI/ARD staff	08nov99	Marriott Hotel, Amman	MWI/ARD staff, and staff of WAJ/JVA, facilitated by MWI/ARD staff	Ministry, JVA and WAJ staff provided their input into the draft workplan for the project, and discussed the place of the project within the context of priority needs for the water sector in Jordan
AQUA 2000 Conference: Wastewater Management for a Better Environment	27apr00-02may00	Abu Dhabi	Eng. Fayez Bataineh, Eng. Yasser Nazzal, Ms. Maysoon Zubi, Eng. Mohamed Najjar (MWI), and Dr. Peter McCornick (ARD)	Presentation and discussion of the following paper: Nazzal, Y. K., M. Mansour, M. Al Najjar, P. G. McCornick. 2000. "Wastewater Reuse Law and Standards in the Kingdom of Jordan." International networking in the water reuse area. Participation in other sessions of the conference and in the workshop on water reuse
Satellite image interpretation and analysis of changes in upland agriculture, organized by MWI/ARD staff	Oct00	MWI	10 MWI staff; instructor was Dr. Lynnette Wood, in association with Nidal H. Saliba of InfoGraph, and assisted by Eng. Tamim Abodaqa	• ten MWI staff gaining an understanding of the basics of remote sensing and image classification, and simulateously received the certificate of successful completion of the ER Mapper 6.1 Training Course; • decision-makers gained insights into practical applications of the technique for water resources planning and management, the limitations, and the logistic and capacity-building required to fully make use of this new technology; and • completed a preliminary classification of the vegetation of the North-East Highlands of the Amman-Zarqa Basin for August, 1999. These results show that remote sensing could be used as a potential monitoring tool for the irrigated cropped area, and therefore for changes in water abstraction, once the analytical procedures have been further refined and validated.

TRAINING	DATES	LOCATION	PARTICIPANTS	OUTPUTS/ACTIVITIES
National Groundwater Association Annual Conference, Las Vegas; Fall Conference of the American Geophysical Union, San Francisco; Site visits to groundwater and reclaimed water facilities in the Los Angeles area.	11dec00-23dec00	Nevada and California	Eng. Edward Qunqar	International networking; participation in the conference theme" Groundwater: a transboundary, strategic and geopolitical resource"; and reviewed policy implementation for groundwater and reclaimed water in California
Groundwater Modeling System (GMS) and FEMWATER training, organized by MWI/ARD staff, and InfoGraph	Jan01	MWI	10 MWI and WAJ groundwater and modeling staff, instructor was Dr. Yahia Majali	Participants learned how the conceptual model for the AZB was specified, and how the various future scenarios were being tested.
Basic Oracle training by Oracle-certified local training company	Jun-Jul01	Amman	Samer Mukattash and Mohamed Akkoub of the WAJ lab staff	This training will enable WAJ staff to better manage the LIMS which is Oracle based.
Stakeholder meeting: review of draft groundwater and water reuse management plans	11jun01	Dead Sea	More than eighty stakeholders, including community leaders, farmers, other users, and staff of local and national government, and independent institutions	Stakeholders collective feedback received, and the interactions developed rapport between the main parties who would be expected to participate in finalizing and implementing the plans
Regional Workshop on Water Reuse in the Middle East and North Africa	01jul01-06jul01	Cairo, Egypt	Eng. Yasser Nazzal	International networking and participation in discussions of latest developments in water reuse in the Middle East, of potential benefit to Jordan